

MALTING TIME OF BREWING BARLEY GRAIN AS A FACTOR MODIFYING THE QUALITY OF PILSNER TYPE MALT

CZAS SŁODOWANIA ZIARNA JĘCZMIENIA BROWARNEGO JAKO CZYNNIK MODYFIKUJĄCY JAKOŚĆ SŁODU TYPU PILZNEŃSKIEGO

Agnieszka ZEMBOLD-GUŁA¹, Józef BŁAŻEWICZ¹, Marek LISZEWSKI²

¹Department of Food Storage and Technology, The Faculty of Food Science,

²Department of Crop Production, The Faculty of Agriculture, Wrocław University of Environmental and Life Sciences, C. K. Norwida 25/27, 50-375 Wrocław, Poland, Fax: +48713205273, e-mail: Agnieszka.Zembold-Gula@wnoz.up.wroc.pl

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ABSTRACT

The research was aimed at determining the effect of malting time of grain of selected varieties of brewing barley cultivated in Poland on the quality of Pilsner type malts, with consideration given to their extractivity and natural losses. The experimental material was barley grain of the following varieties: Class, Blask, Riviera, Lailla, Hanka, Sebastian, Bolina, Philadelphia, Tolar, and Stratus. Grain fractions of >2.5 mm were used to produce 4, 5 and 6-day Pilsner type malts under laboratory conditions. The grain, malt and the resultant worts were evaluated and determined for the malting usability acc. to Molina-Cano. Analyses demonstrated that the 4, 5 and 6-day malting of barley grain enabled obtaining malts with functional parameters corresponding to standard values. Elongation of the malting time from 4 to 6 days does not elicit any significant changes in the extractivity of malt, nor in the malting usability of grain, however it increases natural losses of the malted matter.

KEY WORDS: barley grain, malt, wort, extractivity, natural loss

STRESZCZENIE

Celem pracy było określenie wpływu czasu słodowania ziarna wybranych odmian jęczmienia browarnego uprawianego w Polsce na jakość sładów typu pilzneńskiego, ze szczególnym uwzględnieniem ich ekstraktywności i ubytków naturalnych. Materiałem badawczym było ziarno jęczmienia odmian: Class, Blask, Riviera, Lailla, Hanka, Sebastian, Bolina, Philadelphia, Tolar, Stratus. Z frakcji ziarna o grubości >2,5 mm wyprodukowano w warunkach laboratoryjnych 4, 5 i 6-dniowe sładki typu pilzneńskiego. Ziarno, sład i uzyskane z nich brzezki laboratoryjne poddano ocenie. Określono przydatność słodowniczą ziarna metodą Molina-Cano. Stwierdzono, że 4, 5 i 6-dniowe słodowanie ziarna jęczmienia pozwala na pozyskiwanie sładów o parametrach użytkowych mieszczących się w przedziałach wartości normatywnych. Wydłużanie czasu słodowania z 4 do 6 dni nie powoduje istotnych zmian ekstraktywności sładów, ani przydatności słodowniczej ziarna, zwiększa natomiast ubytki naturalne słodowanej masy.

SŁOWA KLUCZOWE: ziarno jęczmienia, sład, brzezka, ekstraktywność, ubytek naturalny

STRESZCZENIE SZCZEGÓŁOWE

Jakość słodu typu pilzneńskiego jest wypadkową cech odmianowych, przebiegu sezonu wegetacyjnego, zabiegów agrotechnicznych oraz procesu słodowania. W słodownictwie preferowane są odmiany jęczmienia o takiej strukturze bielma, która umożliwia szybką dyfuzję wody w czasie moczenia ziarna, ułatwia transport metabolitów oraz przyspiesza hydrolizę enzymatyczną składników ziarna. Celem pracy było określenie wpływu czasu słodowania ziarna wybranych odmian jęczmienia browarnego uprawianego w Polsce na jakość słodów typu pilzneńskiego, ze szczególnym uwzględnieniem ich ekstraktywności i ubytków naturalnych. Materiałem badawczym było ziarno jęczmienia odmian: Class, Blask, Riviera, Lailla, Hanka, Sebastian, Bolina, Philadelphia, Tolar, Stratus, ocenianych w Katedrze Szczegółowej Uprawy Roślin Uniwersytetu Przyrodniczego we Wrocławiu. Ziarno jęczmienia poddano frakcjonowaniu przy użyciu sit Vögl'a i pozbawiono zanieczyszczeń. Z frakcji ziarna o grubości >2,5 mm wyprodukowano w warunkach laboratoryjnych 4, 5 i 6-dniowe słody typu pilzneńskiego. Ziarno, sól oraz uzyskane z nich brzezki laboratoryjne poddano ocenie. Określono najistotniejsze wyróżniki jakościowe stosowane w laboratoryjnej ocenie słodów i brzezek. Dokonano również oceny przydatności słodowniczej ziarna metodą Molina-Cano, która uwzględnia najistotniejsze cechy jakościowe słodów i otrzymanych z nich brzezek, dobrane zgodnie ze wskazaniami EBC. Metoda ta jest wykorzystywana w Polsce przez COBORU do oceny przydatności słodowniczej ziarna jęczmienia browarnego odmian wprowadzonych do uprawy. Uzyskane wyniki poddano wielokierunkowej analizie wariancji, określono również grupy jednorodne. Z analizy danych wynika, że czas kiełkowania ziarna jęczmienia browarnego odmian aktualnie uprawianych w Polsce nie powoduje zasadniczego zróżnicowania ekstraktywności słodów, ani przydatności słodowniczej ziarna (rys. 1 i 2), a istotne różnice występują w wartościach ubytków naturalnych (rys. 3). Wielkość ubytków naturalnych zależy od cech odmianowych, podobnie jak ekstraktywność (rys. 1) i przydatność słodownicza określona metodą Molina-Cano (rys. 2). Stwierdzono, że 4, 5 i 6-dniowe słodowanie ziarna jęczmienia pozwala na pozyskiwanie słodów o parametrach użytkowych mieszczących się w przedziałach wartości normatywnych. Wydłużanie czasu słodowania z 4 do 6 dni nie powoduje istotnych zmian ekstraktywności słodów, ani przydatności słodowniczej ziarna, zwiększa natomiast ubytki naturalne słodowanej masy.

INTRODUCTION

The quality of Pilsner type malt is a resultant of variety-specific characteristics, the course of the vegetative season, agrotechnological treatments and the malting process [2, 3, 5, 6, 7, 11]. Malting is linked with the penetration of water into a kernel, transfer of metabolites and enzymatic transformations as well as with the emergence and development of the acrospire and the rootlets [9]. The malting industry prefers barley varieties characterized by such a structure of endosperm that enables rapid diffusion of water during the steeping of grain, facilitates transport of metabolites and accelerates enzymatic hydrolysis of grain components [10]. The reported study was aimed at determining the effect of malting time of selected varieties of brewing barley cultivated in Poland on the quality of Pilsner type malts with special emphasis put on their extractivity and natural losses.

MATERIALS AND METHODS

The experimental material was grain of barley of the following varieties: Class, Blask, Riviera, Lailla, Hanka, Sebastian, Bolina, Philadelphia, Tolar, and Stratus. The grain originated from the vegetative season of 2005, from a field experiment conducted by the Department of Plant Cultivation of the Experimental Station in Pawłowie.

The grain was fractionated by means of Vögel screens as well as deprived of contaminations and damaged corns. Grain with fractions of >2.5 mm was used to produce 4, 5 and 6-day Pilsner type malts under laboratory conditions. The steeping and malting of grain samples (200 g) were conducted in perforated foil bags in a climatic cabinet, with temperature kept at a level of 15-16°C. The steeping cycle spanned for 48 h. The grain was kept in water and air atmosphere according to the following scheme: 8 h – in water /w/, 11 h – in air atmosphere /a/, 5 h – w, 8 h – a, 11 h – w, and 5 h – a. The steeping enabled obtaining the assumed final moisture content of 43%. The time of malting was counted from the termination of the steeping cycles and lasted from 4, 5 and 6 days. In the course of the malting process, the grain was weighed and agitated. The resultant malts were kilned in a laboratory wind dryer using the following temperature cycles: 10 h – 30°C, 5 h – 40°C, 3 h – 50°C, 3 h – 65°C, and 2 h – 82°C. After cooling of the kilned malts the rootlets were removed manually. Laboratory (congress) mashing was conducted in a laboratory masher type ZL-1.

Determinations were carried out for the key quality attributes used in the laboratory assessment of malts and worts [1], that were next applied in the assessment of, among others, grain usability acc. to Molina-Cano. That method involves the most important

quality characteristics of malts and the resultant worts (extractivity, Kolbach index, diastatic power, degree of final attenuation of wort and wort viscosity), being of significance to malt producers and brewers and adopted following recommendations of the European Brewery Convention – EBC. Values of those parameters, serving to determine an indicator of brewing quality of a variety (Q), were divided into nine quality classes (1–the worst, 9–the best). The Q indicator is a sum of products of those five parameters and weights ascribed to them (extractivity–0.40, the other characteristics – 0.15 each). Based on the Q indicator, the brewing quality of varieties was divided into six categories: from the non-brewing one, i.e. pasture ($Q < 3.00$) to very good brewing quality ($Q > 7.99$) [8, 10].

The results obtained were subjected to multi-factorial analysis of variance at a significance level of $\alpha = 0.05$. Homogenous groups, denoted in figures with subsequent letters of the alphabet, were determined with the method of multiple comparisons using a Duncan's test. All calculations were performed by means of STATISTICA 8.0 package by StatSoft.

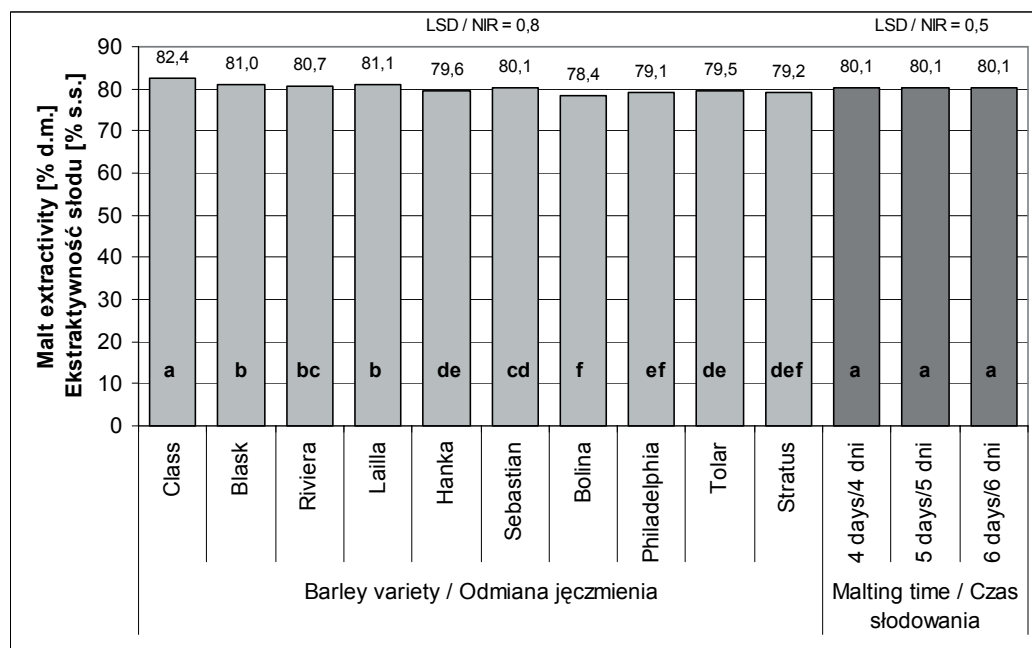
RESULTS AND DISCUSSION

Out of results of the complete evaluation of malting

usability of grain of 10 brewery varieties, data were selected that enable a comparison of the effect of 4, 5, and 6-day malting of grain on the extractivity of malts and size of total natural losses occurring in the entire process of Pilsner types malts production. For more comprehensive presentation of differences in the quality of 4, 5 and 6-day malts the results of laboratory assessment were presented in the form of a synthetic scale acc. to Molina-Cano used by the Research Centre for Cultivar Testing (COBORU) for the evaluation of malting usability of brewing barley grain of varieties introduced into cultivation [8, 10].

Assessments of the malting usability of leading brewing varieties were conducted in order to determine how variety-specific characteristics and time of malting may differentiate characteristics being of importance to malt producers (extent of natural losses of malted grain and extractivity of the resultant malts). It was an attempt of showing the need for determining the optimal time of malting barley grain of various varieties. While introducing a new variety into the specification of cultivable crops, an additional criterion should involve economic aspects, including the yield of malt per unit of cultivable area (e.g. per 1 ha) or the quantity of wort or even beer that may be produced from grain of a given variety cultivated on the area of 1 ha [4].

Extractivity of malts has been changing in recent years,



a, b, c... – homogenous groups / grupy jednorodne ($\alpha = 0.05$); LSD / NIR – last significant difference / najmniejsza istotna różnica ($p = 0.05$)

Figure 1. Extractivity of malt as affected by variety and malting time of barley grain.

Rysunek. 1. Ekstraktywność słodu w zależności od odmiany oraz czasu słodowania ziarna jęczmienia.

which is directly linked with cultivation works aimed at increasing the extractivity of barley grain. Current standards stipulate that the extractivity of barley grain of Pilsner type malts should account for min. 79.5% d.m. [8]. Malts obtained from grain of new varieties of malting barley are characterized by extractivity of over 80% d.m., which is a typical effect of the selection of brewing varieties of barley.

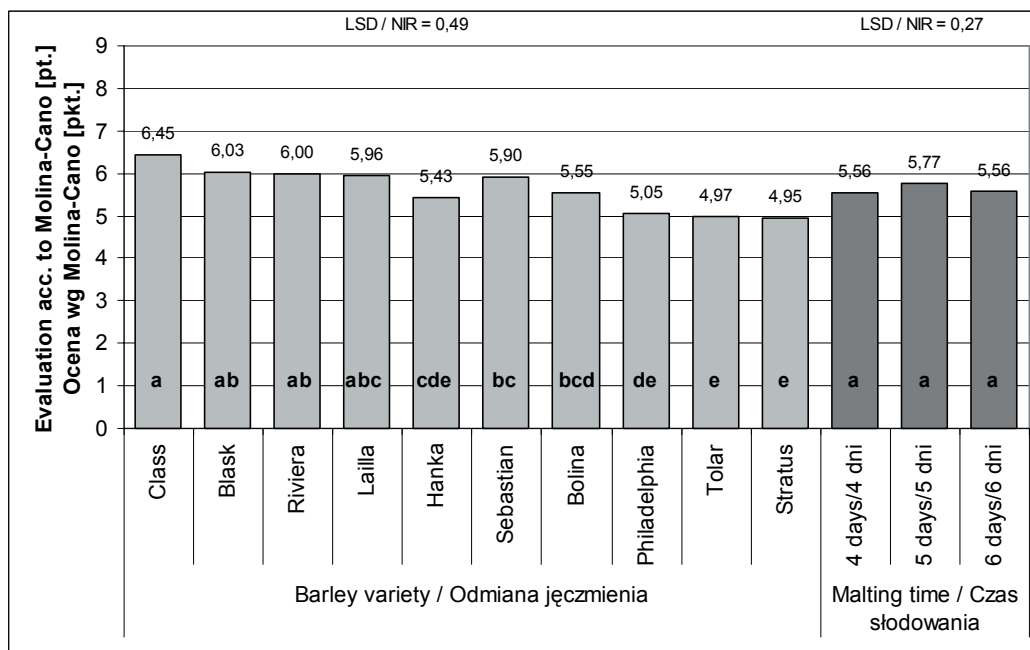
It is obvious that the economics of malt production affects purchase prices of grain of brewing barley. Dependencies determined in this study cannot be confronted with those reported in similar research papers, since such papers have not been published so far in commonly available literature.

The extractivity of Pilsner type malts obtained from 10 varieties of malting barley displayed significant differences of values within varieties (Figure 1). In turn, the time of barley grain germination in the interval of 4 to 6 days did not elicit any significant differences in extractivity values. This was likely to result from an increasing content of extractive substances with their simultaneous utilization during development of kernels.

The available literature lacks data on the time of grain germination during the production of Pilsner type malts. It is an issue considered as a „business secret” of malt producers and constituting one of the elements of malt

production technology protected against competition. The lack of effect of 4-6 day germination of grain on the extractivity of malts, determined in this study, points to a very good modification of endosperm constituents of the grain of the varieties examined. In addition, it indicates that 4-day germination of grain is sufficient to reach good extractivity of malts. Elongation of the time of grain germination (standard in terms of protein content) up to 5 and 6 days does not yield neither positive effects nor deterioration of values of that characteristic.

Figure 2 collates results of the evaluation of malting usability of barley grain of the analyzed varieties acc. to Molina-Cano [8, 10]. The 4, 5 and 6-day period of malting the grain of the leading varieties of brewing barley was demonstrated not to differentiate their malting usability. >From the technological point of view, these are malts of the same value. A lack of considerable effect of germination time of barley grains affords possibilities of obtaining products of the same quality once malting grain both for 6 and 4 days. It points to a vast advance in cultivation works on barley varieties those results in - such a significant to the malting industry - acceleration of enzymatic transformation of the germinating grain. In grain of novel varieties, even 4-day germination assures transformations of endosperm sufficient from the technological point of view.



a, b, c... – homogenous groups / grupy jednorodne ($\alpha=0.05$); LSD / NIR – last significant difference / najmniejsza istotna różnica ($p=0.05$)

Figure 2. Evaluation acc. to Molina-Cano as affected by variety and malting time of barley grain.
Rysunek 2. Ocena wg Molina-Cano w zależności od odmiany oraz czasu słodowania ziarna jęczmienia.

Standards of mass losses during malting refer to older varieties of malting barley. According to Kunze, for light malt the loss of matter during steeping reaches ca. 1%. In the course of biochemical and physiological transformations, grain loses ca. 5.8% of raw material mass for respiration and another 3.7% during the removal of rootlets. In total, for the Pilsner type malt natural losses account for ca. 10.5% of dry matter [9]. Those data are, however, very general and do not consider the impact of malting time nor advance in the cultivation of malting barley. The balancing of matter destined for processing is of crucial significance to the economics of a malting factory. Since those losses cannot be eliminated [9], determination of the extent of losses is of utmost importance.

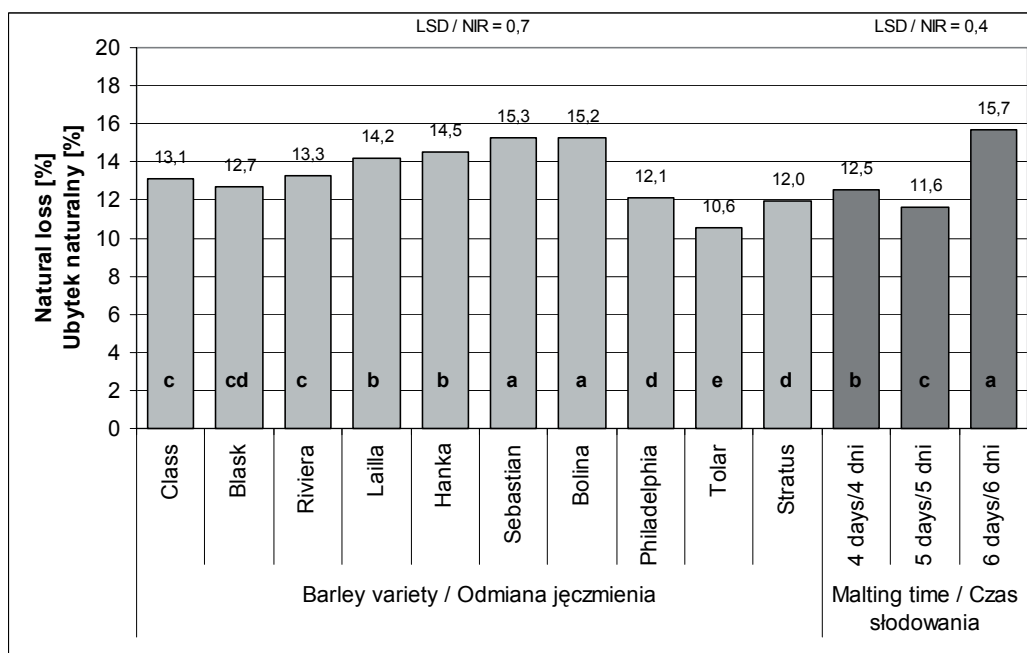
In the reported research, losses of matter were balanced taking into consideration such parameters as: variety and time of grain malting. Experiments were conducted under identical conditions in order to demonstrate the effect of those parameters on the level of natural losses. The natural losses were presented as converted per 1000 corns (1000 of live organisms). In conversion per 100 g of dry matter of grain the result may be burdened with an error linked with the size of corns, since 100 g d.m. may contain a greater and or smaller number of barley corns.

Results depicted in Figure 3 demonstrated that the level of

losses was diversified both by the time of malting as well as by variety-specific characteristics. The statement that elongation of time increases natural losses of the malted matter is obvious. It is linked with the intensification of biochemical and physiological transformations of the grain. Part of substances accumulated in the grain is utilized in respiratory processes and for building an acrospire and rootlets. Analyses conducted in our research demonstrated that grain of most of the novel varieties displayed large losses of matter as early as in day 4 of malting, which was probably linked with enhanced activity of enzymes. The study indicates also that elongation of the malting time of grain of most of varieties only increases the natural losses without increasing the extractivity of the resultants malts. Only a few of the varieties obtained a higher extractivity as a result of 5 or 6-day malting.

The analysis of results demonstrates that the time of germination of brewing barley grain of varieties currently cultivated in Poland does not elicit any significant differences in the extractivity of malts nor in the malting usability of grain (Figure 1 and 2), and the significant differences occur only in natural losses (Figure 3).

The course of the malting process shows that the longer the time of germination of malting barley grain the greater the extent of natural losses of malted matter. It



a, b, c... – homogenous groups / grupy jednorodne ($\alpha=0.05$); LSD / NIR – last significant difference / najmniejsza istotna różnica ($p=0.05$)

Figure 3. Extent of natural losses as affected by variety and malting time of barley grain.

Rysunek 3. Wielkość ubytków naturalnych w zależności od odmiany oraz czasu słodowania ziarna jęczmienia.

is a value dependent on variety-specific traits, likewise extractivity (Figure 1) and malting usability determined with the method of Molina-Cano (Figure 2).

Results obtained in this study demonstrate that the variety-specific factor to a larger extent than the malting time differentiates the extractivity of malts and malting usability of grain assessed with the method of Molina-Cano, which additionally affects the size of natural losses. For this reason, germination time of grain of novel varieties should be shortened to 4-5 days.

CONCLUSIONS

1. Malting for 4, 5 and 6 days enables obtaining malts with functional parameters corresponding to ranges of standard values.
2. Elongation of the malting time of barley grain from 4 to 6 days does not elicit any significant changes in the extractivity of malts nor in the malting usability of grain, yet it increases natural losses of the malted matter.

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